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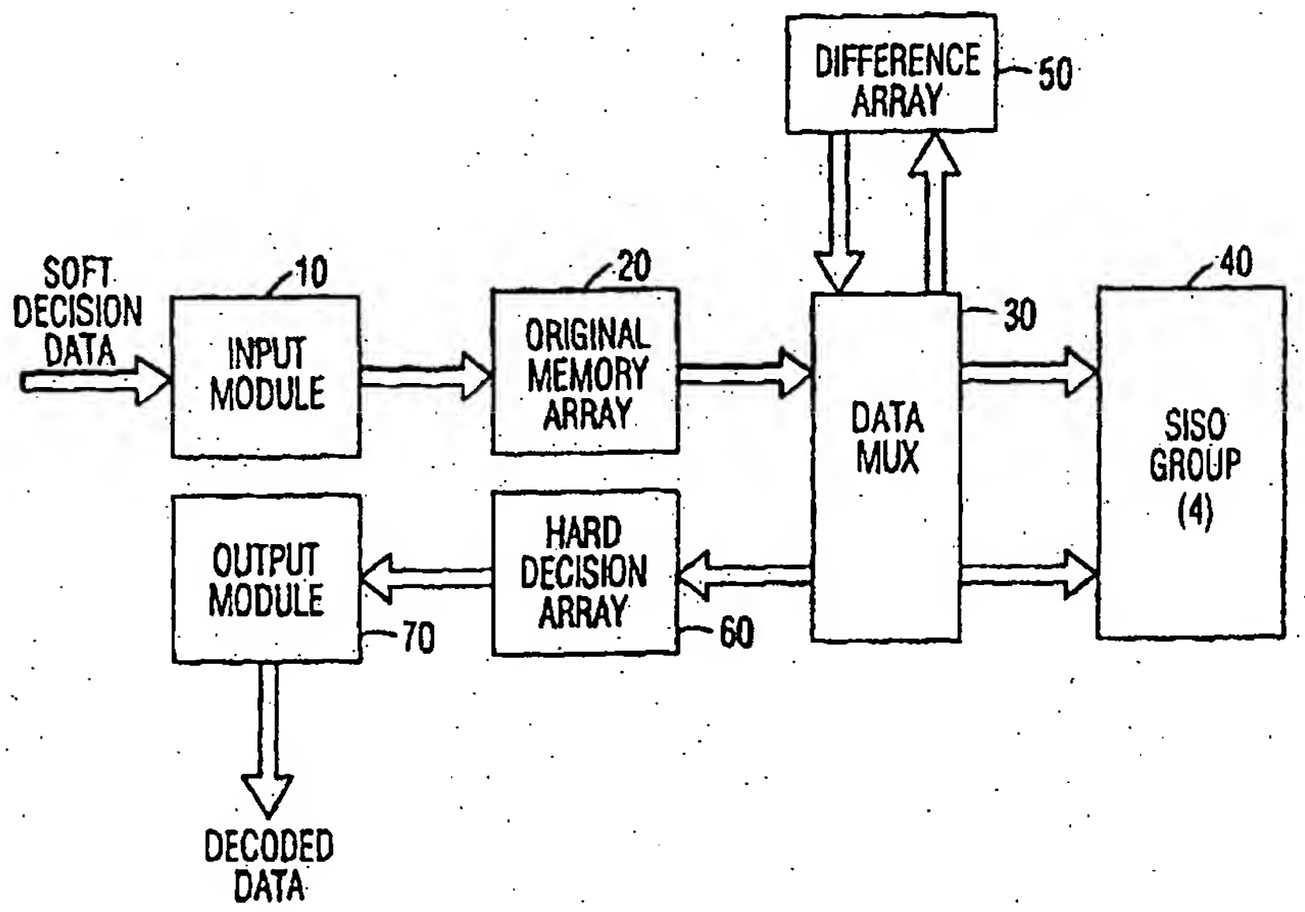
(54) Title: TURBO PRODUCT CODE DECODER

(57) Abstract

The present invention is a turbo product code decoder capable of decoding multi–dimensional coding schemes. The decoder may be implemented in any digital communication system capable of receiving an encoded stream of data. The decoder is configured for receiving soft decision values. The decoder iteratively decodes the data by generating new soft difference values for each axis–iteration of decoding. These soft difference values represent the change in soft decision values after each axis–iteration. The soft difference values from each axis–iteration are then summed with the original soft decision values in decoding each of the other axis. After any full iteration — i.e. after all axis dimensions have been decoded one full time, the previous difference values for any axis are discarded when that axis is decoded in subsequent iterations. Accordingly, the same information is not continuously fed into the decoder during each subsequent iteration, thereby decreasing the likelihood of error and offering an improvement over prior decoders. Moreover, using unique nearest neighbor computation logic, the decoder of the present invention is able to generate valid nearest neighbors more efficiently without requiring the use of a look–up table, thereby reducing the amount of time required to decode. Finally, the decoder of the present invention utilizes four decoders arranged in parallel along with a unique memory array accessing scheme such that multiple rows or columns may be decoded at the same time, thereby increasing the data throughput time of the decoder over prior turbo product code decoders.



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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/22441

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H03M13/29 H03M13/45

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H03M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
INSPEC, COMPENDEX, WPI Data, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PICART A ET AL: "PERFORMANCE OF TURBO-DECODED PRODUCT CODES USED IN MULTILEVEL CODING" IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC),US,NEW YORK, IEEE, 1996, pages 107-111, XP000625651 ISBN: 0-7803-3251-2 page 107, right-hand column, line 25 - line 29	1-3, 12-14, 18,19, 22-28
A	page 108, right-hand column, line 1 - line 12	15-17, 20,21

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 July 2000	17 08 2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Georgiou, G

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/22441

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	GOALIC A ET AL: "REAL-TIME TURBO-DECODING OF PRODUCT CODES ON A DIGITAL SIGNAL PROCESSOR" GLOBAL TELECOMMUNICATIONS CONFERENCE (GLOBECOM),US,NEW YORK, IEEE, 1997, pages 624-628, XP000737614 ISBN: 0-7803-4199-6	29,30
A	page 624, paragraph II	31
P,X	ADDE P ET AL: "DESIGN AND PERFORMANCE OF A PRODUCT CODE TURBO ENCODING-DECODING PROTOTYPE" ANNALES DES TELECOMMUNICATIONS - ANNALS OF TELECOMMUNICATIONS,CH,PRE SSES POLYTECHNIQUES ET UNIVERSITAIRES ROMANDES, LAUSANNE, vol. 54, no. 3/04, March 1999 (1999-03), pages 214-219, XP000834643 ISSN: 0003-4347	29,30
A	page 216, paragraph III.2	31
X	EP 0 625 829 A (AT & T CORP) 23 November 1994 (1994-11-23)	29
A	page 3, line 34 - line 51; claim 1; figure 4	30,31

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 99/22441

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-28

Turbo product code decoder which performs iterative decoding of product codes.

2. Claims: 29-31

Method of decoding linear block encoded strings by performing a soft decision calculation for each codeword and comparing the result to a certain number of legitimate codewords.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/22441

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0625829 A	23-11-1994	US 5457704 A	10-10-1995
		AU 673251 B	31-10-1996
		AU 6321994 A	24-11-1994
		DE 69421963 D	13-01-2000
		DE 69421963 T	13-07-2000
		ES 2142375 T	16-04-2000
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		SG 43207 A	17-10-1997